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Heavy commercial vehicles — Vehicle stability during tipper body operation — Tilt-table test method

Véhicules utilitaires lourds — Stabilité du véhicule pendant l'utilisation de benne basculante — Méthode d'essai avec table basculante

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Contents

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A test method is presented for estimating the steady-state rollover threshold of vehicles with a tipper body, using a tilt table device at different inclination angles of the tipper body. Knowledge of a vehicle unit's lateral stability limits during tipping operation is important to prevent rollover, understand operational safety limits, and validate vehicle modelling and design efforts.

Heavy commercial vehicles — Vehicle stability during tipper body operation — Tilt-table test method

1 Scope

This document provides a tilt-table test method for estimating vehicle lateral stability during tipping (or dump) operations. The test method results in a limit curve that creates an envelope of the tipper vehicle unit's rollover threshold, at different tipper body inclinations. This document is applicable to both rear and side tipping vehicles.

This document applies to heavy commercial vehicles and commercial vehicle combinations, as defined in ISO 3833, equipped with rearward or sideways tipping (or dump) bodies (trucks and trailers with maximum weight above 3,5 tonnes, according to ECE and EC vehicle classification, categories N2, N3, O3 and O4).

NOTE The stability envelope can be applied to autonomous construction vehicles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8855, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 15037-2:2002, *Road vehicles — Vehicle dynamics test methods — Part 2: General conditions for heavy vehicles and buses*

ISO 16333:2011, *Heavy commercial vehicles and buses — Steady-state rollover threshold — Tilt-table test method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-2 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
tipper body
device on a commercial vehicle unit that contains the payload and can be rotated around an axis

Note 1 to entry: Unloading in a tipping operation is performed by tilting the tipper body around its pivot axis until the payload is discharged.

Note 2 to entry: In some countries this term is more commonly known as a dump body.

3.2
tipping hinge
revolute joint between the *tipper body* (3.1) and associated subframe, forming the axis about which the tipper body revolves during a tipping operation

3.3
sideways tipping
tipping operation performed with the *tipper body* (3.1) pivot axis nominally parallel to the x-axis of the vehicle

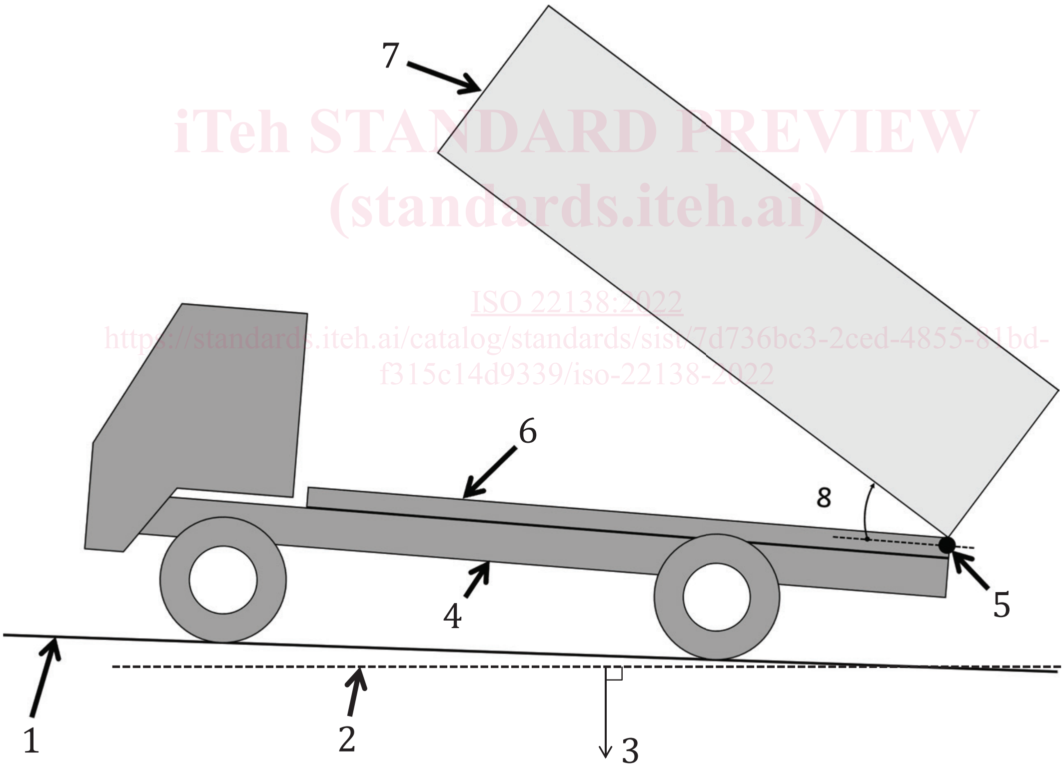
Note 1 to entry: This is principally a roll motion of the tipper body.

3.4
rearward tipping
tipping operation performed with the *tipper body* (3.1) pivot axis nominally parallel to the y-axis of the vehicle

Note 1 to entry: This is principally a pitch motion of the tipper body.

3.5
tipper body pitch angle
θ_B
pitch angle between the chassis frame and the *tipper body* (3.1), to be measured within a distance less than 1 000 mm from the *tipping hinge* (3.2)

Note 1 to entry: See Figure 1.



Key

1 road plane
2 ground plane
3 gravity vector
4 chassis frame
5 tipping hinge
6 subframe
7 tipper body
8 tipper body pitch angle (θ_B)

Figure 1 — Side view of tipper vehicle with rearward tipping

3.6
chassis frame pitch angle
θ_{Ch}
pitch angle between the chassis frame and the ground plane, to be measured within a distance less than 1 000 mm from the *tipping hinge* (3.2)

Note 1 to entry: See Figure 2.

Note 2 to entry: Chassis frame pitch angle includes contributions from *road plane elevation angle* (3.9) (see ISO 8855:2011, 2.7.1), chassis suspension pitch, tyre compression, etc.

3.7
angle of repose
α
steepest angle at which a sloping surface formed of a particular loose material is stable

3.8
global tipper body pitch angle
θ_G
pitch angle between the *tipper body* (3.1) and the ground plane

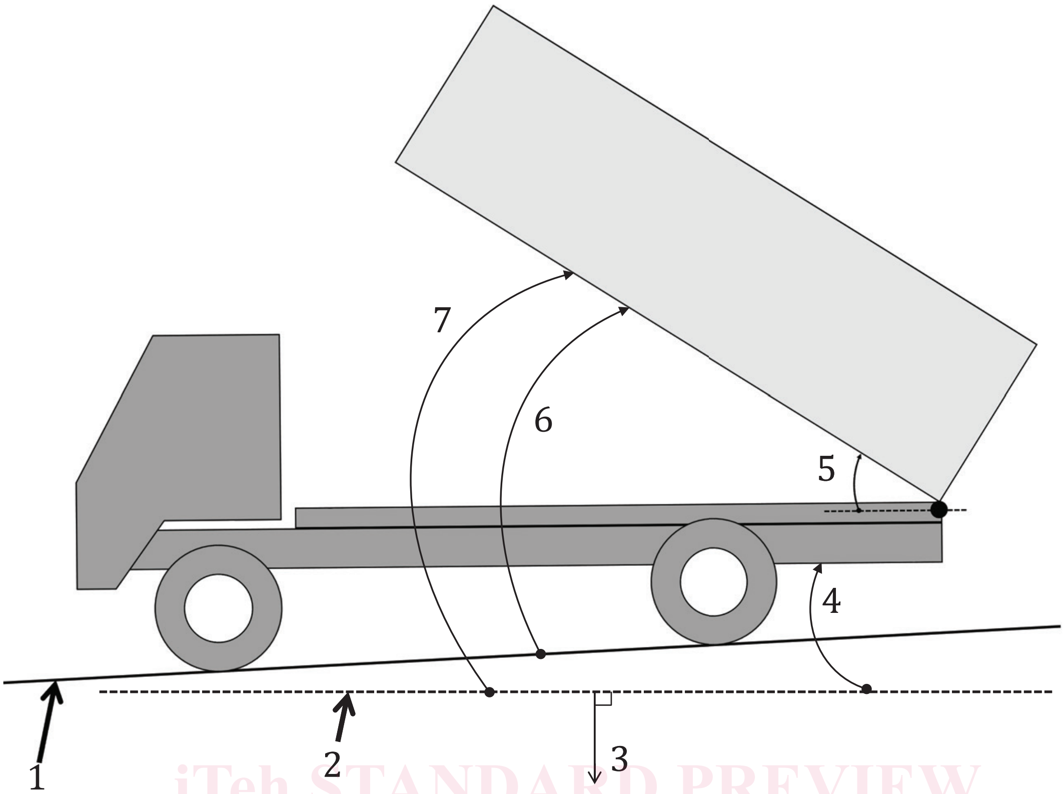
Note 1 to entry: It is calculated as the sum of *chassis frame pitch angle* (3.6) and *tipper body pitch angle* (3.5), which is $\theta_G = \theta_{Ch} + \theta_B$.

Note 2 to entry: See Figure 2.

Note 3 to entry: This angle is influenced by the payload's *angle of repose* (3.7).

3.9
road plane tipper body pitch angle
θ_R
pitch angle between the *tipper body* (3.1) and the road plane

Note 1 to entry: See Figure 2.



Key

1 road plane
2 ground plane
3 gravity vector
4 chassis frame pitch angle (θ_{Ch})
5 tipper body pitch angle (θ_B)
6 road plane tipper body pitch angle (θ_R)
7 global tipper body pitch angle (θ_G)

Figure 2 — Tipper vehicle pitch angles

3.10
tilt table
apparatus for supporting a vehicle on a nominally planar surface and for tilting the vehicle in roll by rotating that surface about an axis nominally parallel to the x-axis of the vehicle

Note 1 to entry: A tilt table is composed of a single structure supporting all tyres of the vehicle on a contiguous surface, alternatively multiple structures supporting one or more axles on separated but nominally coplanar surfaces.

3.11
tilt axis
axis around which the *tilt table* (3.10) rotates, nominally parallel to the x-axis of the vehicle

3.12
tilt angle
ϕ_T
angle between the ground plane and a vector that is in the plane of the *tilt table* (3.10) surface and is perpendicular to the *tilt axis* (3.11)

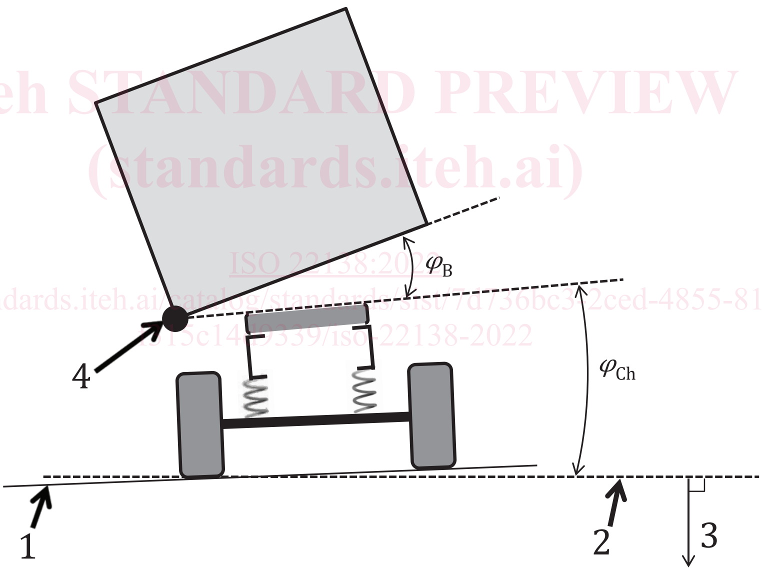
3.13
critical wheel lift
first moment when one or more wheels lifts from the table surface, following which stable roll equilibrium of the vehicle cannot be maintained

3.14
trip rail
rail or kerb fixed to the *tilt table* (3.10) surface and oriented longitudinally beside the low-side wheels when tipping in the vehicles roll direction, to prevent the vehicle from sliding sideways

3.15
critical tilt angle
ϕ_{Tc}
tilt angle (3.12) at *critical wheel lift* (3.13)

3.16
tipper body roll angle
φ_B
roll angle between the chassis frame and the *tipper body* (3.1), to be measured within a distance less than 500 mm from the *tipping hinge* (3.2)

Note 1 to entry: See Figure 3.



Key
1 road plane
2 ground plane
3 gravity vector
4 tipping hinge

Figure 3 — Rear view of sideways tipping vehicle

3.17
chassis frame roll angle
φ_{Ch}
roll angle between chassis frame and the ground plane, to be measured within a distance less than 500 mm from the *tipping hinge* (3.2)

3.18
global tipper body roll angle
φ_G
roll angle between *tipper body* (3.1) and ground plane

Note 1 to entry: It is equal to the sum of *the chassis frame roll angle* (3.17) and the *tipper body roll angle* (3.16) $\varphi_G = \varphi_{Ch} + \varphi_B$.

4 Principle

This document specifies a test method for determining vehicle lateral stability during tipping operation. The tipper stability test conducted on a tilt table is a physical simulation of the roll-plane quasi-static response of a tipper vehicle subjected to a roll moment. In real-world operation, the roll moment may result from tipper body use, as well as uneven lateral loading (e.g. generated by uneven discharge during tipping operation), side-slope conditions of the road plane, deformation of the road surface at one wheel, strong side-wind and similar.

In this test method, the tipper vehicle, with a given tipper body pitch or roll angle, is installed on a tilt table with the vehicle's longitudinal axis oriented parallel to the tilt axis. The roll moment is gradually increased by increasing the tilt angle, until the vehicle becomes unstable in roll, as shown in Figure 4. Safety restraints or supports are used to prevent the actual complete rollover of the vehicle. The test is repeated for several tipper body pitch or roll angles, respectively, to generate an envelope of the tipper vehicle's stability performance, both with respect to tipper body angle and tilt angle. In the case of rearward tipping vehicle, the tyres of the first axle should be in contact with the tilt table surface at the start of each test attempt.

As the tilt angle increases during the test, vertical load is gradually transferred from the tyres on one side of the vehicle (high-side) to the other side (low-side). Tyres on the unloaded high-side will eventually lift from the tilt table surface. Typically, wheel lift does not take place simultaneously for all axles. In many cases, lift-off occurs at different tilt angles for each axle. The increase of tilt angle should be stopped simultaneously with the vehicle becoming unstable in roll. Safety restraints or supports should be arranged in such a manner that the roll motion of the vehicle is arrested immediately after critical wheel lift occurs.

ISO 16333:2011, Annex B presents a discussion on the conceptual and practical sources of error when using a tilt table, which are applicable to the test method in this document.

Results from this test method are valid for the conditions present during test execution. During unloading of a tipper vehicle, conditions may vary (wind speed, road surface inclination, payload distribution, etc.), which shall be considered when comparing test results with real-world tipper operation. See Annex C for additional information on the stability envelope of tipper vehicles and a comparison of test results with real life tipper operation.

